J. Raptor Res. 37(1):31–36

DIFFERENTIAL SPRING MIGRATION OF ADULT AND JUVENILE LEVANT SPARROWHAWKS (*ACCIPITER BREVIPES*) THROUGH EILAT, ISRAEL

Reuven Yosef[1]
International Birding and Research Centre in Eilat, Department of Life Sciences, Ben-Gurion University of the Negev, P.O. Box 774, Eilat 88000, Israel

Lorenzo Fornasari
Department of Environmental Sciences, University of Milano Bicocca, Piazza della Scienza 1, I-20126, Italy

Piotr Tryjanowski
Department of Avian Biology and Ecology, Adam Mickiewicz University, Fredry 10, PL-61-701 Poznań, Poland

Marc J. Bechard and Gregory S. Kaltenecker
Idaho Bird Observatory, Department of Biology, Boise State University, 1910 University Drive, Boise, ID 83725 U.S.A

Keith Bildstein
Hawk Mountain Sanctuary, 1700 Hawk Mountain Road, Kempton, PA 19529 U.S.A.

Abstract.—As many as 50 000 Levant Sparrowhawks (*Accipiter brevipes*) are counted during migration at the northern end of the Gulf of Aqaba each spring. We present data from 1819 migrants that were captured and ringed at Eilat, Israel: 459 from 1984–88, 21 from 1989–95, and 1345 captured from 1996–2000. Of these, 396 (22%) were adult females, 631 (35%) were adult males, 359 (20%) were juvenile females, and 433 (24%) were juvenile males. We compare migration timing and body sizes in juvenile (i.e., first-time spring migrants) and adult migrants, and in males and females. Wing chord length and body mass in males and females changed significantly with date of arrival. Further, a significant correlation was found for both sexes between wing chord length and body mass in spring. Within age classes, both wing chord and body mass declined significantly with date of ringing. Body mass was also significantly related to size obtained from PCA analyses (PC1), both in males and females. We computed also standardized residuals of body mass on PC1. Date of passage was also significantly correlated to the standardized residuals, both in males and females. This suggested, testing for allometry vs. isometry, that birds in better than expected 'condition' migrated earlier. Moreover, results from analysis of variance revealed that body mass and age were significantly related to the date of passage. The median date of passage for adults preceded that of juveniles by 2.5 days. We believe juveniles on their first spring passage migrate slower than adults and that they are more likely to be later and in poorer body condition.

Key Words: *Levant Sparrowhawk;* Accipiter brevipes; *age; Eilat, Israel; sex; spring migration.*

MIGRACIÓN DIFERENCIAL DE PRIMAVERA ENTRE ADULTOS JUVENILES DEL AZOR DEL MEDITERRÁNEO ORIENTAL (*ACCIPITER BREVIPES*) A TRAVES DE EILAT, ISRAEL

Resumen.—Tantos como 50 000 azores del mediterráneo oriental (*Accipiter brevipes*) son contados durante su migración en el limite del golfo de Aqaba cada primavera. Presentamos datos de 1819 emigrantes que fueron capturados y anillados en Eilat, Israel: 459 de 1984–88, 21 de 1989–95, y 1345 capturados entre 1996–2000. De estos, 396 (22%) fueron hembras adultas, 631 (35%) eran machos adultos, 359 (20%) hembras juveniles, y 433 (24%) machos juveniles. Comparamos el tiempo de migración y los tamaños del cuerpo en emigrantes juveniles (v.gr., azores migrantes que lo hacían por primera vez en primavera) y adultos, y en machos y hembras. La longitud de la cuerda del ala y la masa del cuerpo en

[1] E-mail address: ryosef@eilatcity.co.il

machos y hembras cambió significativamente con la fecha de arribo. Por otro lado, se encontró una correlación significativa para ambos sexos entre la longitud de la cuerda del ala y la masa corporal en primavera. Dentro de las clases de edad, tanto la longitud de la cuerda del ala como la masa del cuerpo declinó significativamente con la fecha del anillado. Las masas corporales además estuvieron relacionadas significativamente al tamaño obtenido mediante análisis PCA (PC1), tanto en machos como hembras. Calculamos además residuos estandarizados de masa corporal en PC1. La fecha de paso estuvo también correlacionada significativamente con los residuos estandarizados, tanto en machos como en hembras. Esto sugiere, haciendo pruebas de alometría vs. isometría, que las aves en mejor "condición" que la esperada, migraban más temprano. Por otra parte, los resultados del análisis de varianza revelan que la masa del cuerpo y la edad estuvieron relacionadas significativamente con la fecha de paso. La fecha promedio para los adultos precedía a la de los juveniles en 2.5 días. Creemos que los juveniles en su primera pasada de primavera migran mas lento que los adultos y que son más propensos a estar retrasados y en condiciones corporales mas pobres.

[Traducción de César Márquez]

The Levant Sparrowhawk (*Accipiter brevipes*) breeds principally within the western Palearctic Region, in southeast Europe, locally through Turkey to northern Iran, and is widespread in southwest Russia and Kazakhastan (Snow and Perrins 1998). It winters in the east Sahel of sub-Saharan Africa, and sporadic reports are received also from the Ethiopian highlands and the southern Arabian Peninsula (Snow and Perrins 1998, Shirihai et al. 2000). Principal migration routes lie entirely within the Middle East (Frumkin et al. 1995, Shirihai et al. 2000) with especially large concentrations found at Eilat during spring (Shirihai and Christie 1992, Yosef 1995).

In Israel, the Levant Sparrowhawk is an abundant migrant in both spring and autumn and about 90% of the world population of the species passes through Israel within a short period of a fortnight (Shirihai et al. 2000), and this is the only raptor known to migrate at night in the region (Stark and Liechti 1993). Visible migration surveys conducted since 1977 suggest that Eilat is an important stopover site for the species in spring. Eilat is at the northern edge of the Sahara and Sinai deserts, and in spring many northbound migrants stop there to rest and feed (Safriel 1968, Yosef 1996a). Levant Sparrowhawks were trapped and ringed at and around Eilat during spring (mid-April through early May) from 1984–2000 (Clark and Yosef 1997, Yosef and Fornasari 2000). In this paper, we present morphometric data collected after capture to compare age- and sex-related differences in body size and migration timing in this species.

STUDY AREA AND METHODS

Levant Sparrowhawks were captured and ringed at and around Eilat, Israel (29°33′N, 34°57′E), using bow-nets, mist nets, dho-gazas, box traps, and Bal-chatri traps (Clark and Yosef 1997). All data were pooled because 63% of Levant Sparrowhawks were caught in 7-m-high mist nets in the early mornings when the flocks started the day's migration. We assumed that these birds represent a sample of the general population because the majority was not trapped with food as bait (Gorney et al 1999). All captured individuals were aged, sexed, measured (including unflattened wing chord), and weighed Aging was based on plumage, molt, and iris color (Clark and Yosef 1998). In addition, birds divided into two categories: juveniles—in second calendar year (SY) and adults—after second calendar year (ASY). Data presented in this paper were collected during 1984–88 (Gorney and Yom Tov 1994, Gorney et al. 1999), 1989–95 (Yosef and Fornasari 2000), and 1996–2000 (Clark and Yosef 1997, Shirihai et al. 2000). We excluded from the analyses five birds (two identified as female and three as male) because according to the biometrics we consider them to have been sexed incorrectly.

Owing to differences in weather and other local conditions which influence the phenology of migration (median test, $\chi^2 = 294.5$, df = 13, $P < 0.0001$), data were standardized between years. By computing the median date of passage for each year, data were collected. Then the dates of all captured hawks were transformed as values before (minus) or after (plus) the median.

All the basic statistics were performed according to Sokal and Rohlf (1995). We computed correlation between birds' measurements and timing of migration (in Julian dates). However, because in accipiters wing chord is an indicator of body size (e.g., Mueller and Meyer 1985, Wyllie and Newton 1994), we established a condition index. We used a total body-size measurement, which was obtained from the principal component analysis with VARIMAX rotation of four (wing chord, culmen, hallux, and tail length) log-transformed, external measurements (Piersma and Davidson 1991) computed separately for the sexes. All morphometric variables had positive and a similar magnitude of loading on the first component (0.318–0.742, eigen value = 1.811, 45.3% of total variance explained for females and 0.234–0.636; eigen value = 1.577, 39.4% of total variance explained for males) We analyzed structural size (PC1)/mass relationships separately within four age/sex classes to test for allometry or isometry.

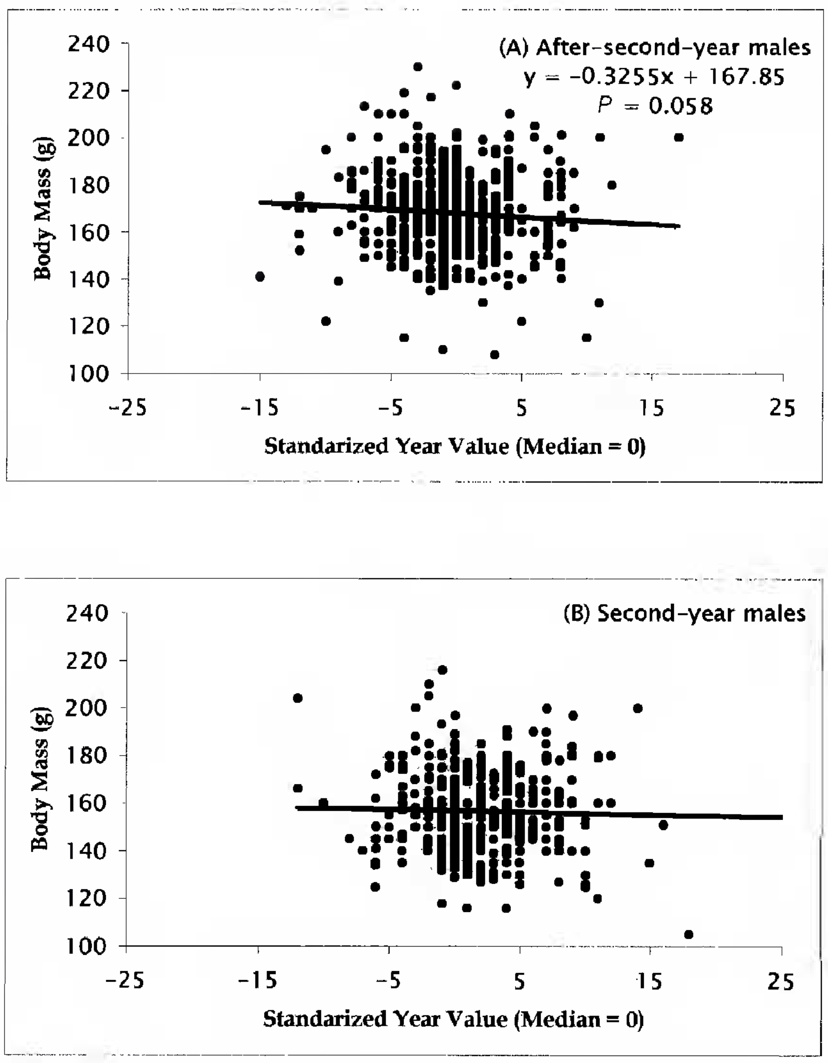

Figure 1. Body mass of (A) after-second-year (ASY) and (B) second-year (SY) male Levant Sparrowhawk in relation to date of capture and passage at Eilat. Regression line is non-significant for SY males.

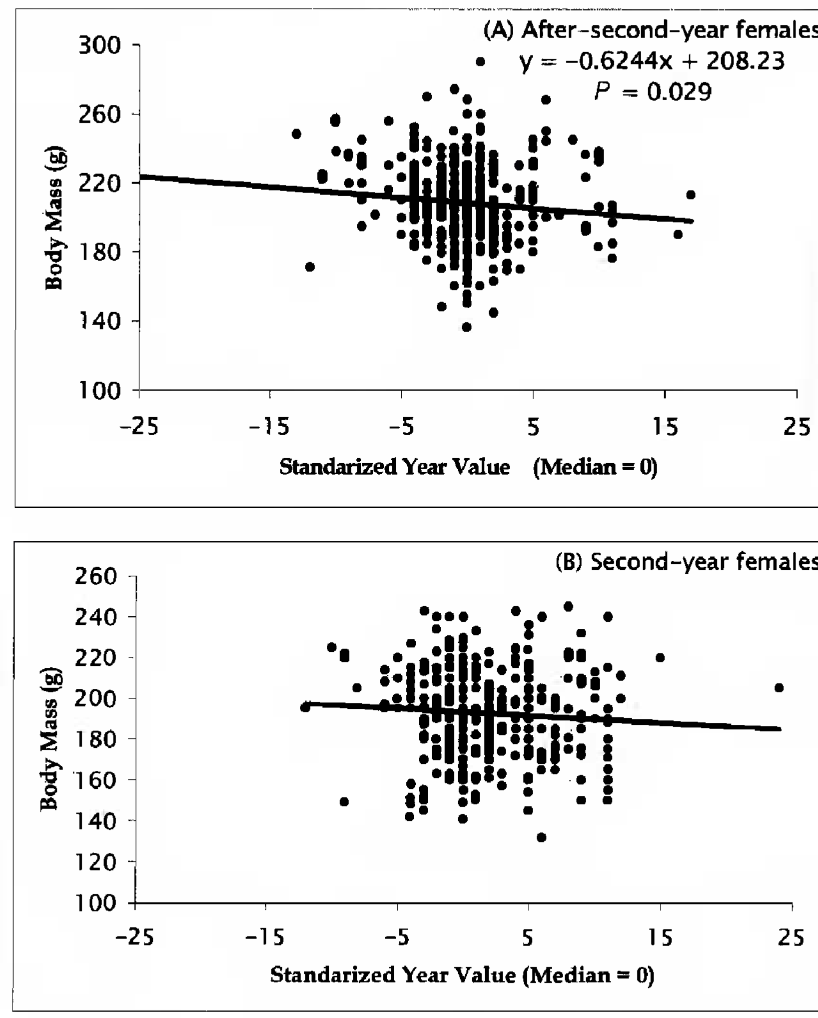

Figure 2. Body mass of (A) after-second-year (ASY) and (B) second-year (SY) female Levant Sparrowhawk in relation to date of capture and passage at Eilat. Regression line is non-significant for SY females.

RESULTS

A total of 1819 migrant Levant Sparrowhawks was captured: 459 in 1984–88, 21 in 1989–95, and 1345 in 1996–2000. Of these, 396 (22%) were adult females, 631 (35%) were adult males, 359 (20%) were juvenile females, and 433 (24%) were juvenile males. Sex ratio among juvenile birds differed significantly from 1:1 (χ^2 = 27.4, $P < 0.0001$), but was not significantly different in adults (χ^2 = 3.6, P = 0.06). Hence, sex ratio between the two age categories differed significantly (χ^2 = 8.4, P = 0.004).

Each spring, transients were trapped in Eilat between early March and early May. The two sex and two age groups differed significantly in their median time of migration (SY females median date = 27 April, range = 10 March–15 May; ASY females median date = 24 April, 18 March–16 May; SY males, 27 April, 18 March–21 May; ASY males, 25 April, 28 March–12 April; Kruskal-Wallis test, χ^2 = 142.36, df = 3, $P < 0.0001$). A *post-hoc* Dunn's *Q*-test ($P < 0.05$) demonstrated that significantly more ASY individuals of both sex migrate earlier than SY birds.

Wing chord length in males ($r_{1030} = -0.207$, $P < 0.0001$) and females ($r_{744} = -0.127$, $P = 0.001$) changed significantly with date of arrival, as did body mass in males ($r_{1022} = -0.141$, $P < 0.0001$; Fig. 1) and females ($r_{740} = -0.137$, $P < 0.0001$; Fig. 2) changed significantly with date of arrival. Further, a significant correlation was found for both sexes between wing chord length and body mass in spring (males y = 0.140 (±0.011) x + 0.367, t = 12.61, $P < 0.0001$ versus females y = 0.128 (±0.011) x + 0.380, t = 11.17, $P < 0.0001$). In addition, we found a significant correlation between mass (log transformed before analyses) and wing chord length for juveniles ($r_{1006} = 0.625$, P < 0.0001) and adults ($r_{783} = 0.665$, $P < 0.0001$). However, there was no statistical difference between the correlation values for the two-age classes (P = 0.152).

Body mass was also significantly correlated with size obtained from PCA analyses (PC1), both in males: $r_{597} = 0.368$, $P < 0.0001$ and females: r_{740} =

Table 1. Analysis of Variance analyses of biometric values of Levant Sparrowhawks related to migration passage at Eilat, Israel.

Source of Variation	Sum of Squares	df	F	P
Covariates	166.525	2	3.978	0.019
Body mass	134.968	1	6.448	0.011
Wing chord	4.626	1	0.221	0.638
Main effects	139.636	2	51.107	<0.001
Age	1755.369	1	83.856	<0.001
Sex	0.147	1	0.007	0.933
2-way interactions				
Age*Sex	30.493	1	1.457	0.228
Explained	3301.656	5	31.545	<0.0001
Residual	37 218.904	1778	20.933	
Total	40 520.560	1783	22.726	

0.330, $P < 0.0001$. We computed also standardized residuals of body mass on PC1. Date of passage was significantly correlated to the standardized residuals, both in males: $r_{598} = -0.154$, $P < 0.0001$ and females: $r_{349} = -0.110$, $P = 0.040$. This suggested, testing for allometry versus isometry, that birds in better than expected 'condition' migrated earlier. Moreover, results from Analysis of Variance revealed that only body mass and age were significantly related to the date of passage (Table 1).

Discussion

In many raptors, adults migrate earlier in spring than do juveniles (Newton 1979, Gorney and Yom-Tov 1994, Yosef et al. 2002). With an overall 10-yr median trapping date of 25 April for adults versus 27 April juveniles, our results, which extend an earlier 5-yr study of Gorney et al. (1999), confirm that Levant Sparrowhawks in Israel, too, exhibit age-related differences in the timing of migration. Although age differences in raptor migration are not completely understood, previous work suggests that such differences occur because breeding pressures on adults select for earlier arrival on the breeding grounds (Newton 1979, Gorney and Yom-Tov 1994), juveniles require more time either to initiate or complete their journeys, or both (Gorney and Yom-Tov 1994, Gorney et al. 1999) or alternatively, juveniles may over-winter farther from their breeding grounds than do adults (Król 1983).

Gorney and Yom-Tov (1994) argued that earlier passage of adult steppe Common Buzzards (*Buteo buteo vulpinus*) at Eilat suggested that adults were "time selected" migrants, whereas juveniles were "energy-selected" migrants. Because most juvenile birds do not breed, they would not need to reach their "breeding grounds" as early in spring as adults. We offer another explanation: that adults precede juveniles because they are better prepared and more efficient at migration, therefore, are more capable and faster migrants en route. Little is known about the Levant Sparrowhawks on their breeding grounds in Eurasia, and the species has yet to be studied in detail on its wintering grounds in Africa (Shirihai et al. 2000). The fact that adults arrive in Eilat only a few days earlier than juveniles and because adults are heavier than juveniles, in our view, suggests that adults are more capable migrants, rather than that the age classes are using different migration strategies. However, it is also possible that age classes winter in separate regions, at different distances from Eilat, resulting in discrepancy in phenology between the two classes. However, the latter cannot be verified at present owing to the lack of data and observations for the species from the wintering grounds. Another possible explanation is that the different age classes may have different migration strategies because adults have longer wings and tails in the spring (Yosef and Fornasari 2000). Proportionally longer wing and tail length allow for a greater proportion of time spent in soaring flight, which is in contrast to juveniles who have shorter wing and tail which requires comparatively more flapping flight that requires greater fat reserves and better body condition.

Soaring migrants such as Levant Sparrowhawks (Spaar 1997, Spaar et al. 1998) typically travel in large flocks, presumably so that individuals can more quickly locate thermals needed to assist their long-distance movements (Kerlinger 1989). Observations of Broad-winged Hawks (*Buteo platypterus*) in North America suggest that juveniles are more likely to be wind drifted and blown off course than are adults (Hagar 1988, Hoffman and Darrow 1992). It is thought that coastal raptor migrations consist primarily of juveniles of all species because of this fact (Kerlinger 1989). We propose that juvenile Levant Sparrowhawks pass through Eilat later than adults because they are less efficient migrants as shown by their lower body weights and lower 'condition' (Clark and Yosef 1997, Gorney et al. 1999).

Although Gorney et al. (1999) found no significant associations between condition indices of adults and juveniles, we believe that large numbers of Levant Sparrowhawks, particularly immatures, reach Eilat in poor body condition. Many raptors ringed at Eilat have tar and oil residues on their feathers and feet (Clark and Gorney 1987). Perhaps they mistakenly land in oil fields of the Sahara and Sinai deserts in search of fresh water during migration flights (Clark and Gorney 1987). Data collected from 1996–2000 indicate that 81% (N = 43) of oil-contaminated Levant Sparrowhawks were juveniles. We assume that juveniles are more stressed during migration, and therefore, more likely to seek drinking water.

Gorney et al. (1999) found no significant associations within age and sex groups between date of migration and physical condition. In contrast, our study shows that birds with longer wing chords and greater body mass passed through the area earlier than smaller individuals of the same sex and age class. In this study, we find that wing chord was significantly correlated with body mass, suggesting that while on migration, larger birds are heavier. Gorney and Yom-Tov (1994) suggest that the large proportion of immatures ringed at Eilat may have resulted from age differences in migration routes as has been reported for other raptor species (Bildstein et al. 1983, Yosef 1996b, Yosef and Alon 1997). No evidence suggests that adult Levant Sparrowhawks follow a different migration route than juveniles (Shirihai and Christie 1992, Shirihai 1996, Shirihai et al. 2000). Rather, geography of the region (Shirihai et al. 2000, Zalles and Bildstein 2000) suggests that northern end of the Gulf of Eilat serves as a concentration point for many western Palearctic migrating raptor species during spring, regardless of age or sex (Spaar et al. 1998). We think that the limited sample size included by Gorney and Yom-Tov (1994) and Gorney et al. (1999) in their study may have led them to conclusions not supported by our data set, which includes more than double in the number of birds involved in the previous analyses.

In conclusion, the fact that within sex and age classes, heavier and better 'condition' individuals are trapped early in the season suggests that in both juveniles and adults, the more efficient migrants pass earlier than less efficient migrants, and that adults are more efficient than juveniles.

ACKNOWLEDGMENTS

We thank the many organizations and individuals who have helped the International Birding and Research Centre through the years, W.S. Clark, Dayton Baker of the National Aviary in Pittsburgh, World Wildlife Fund-International, Sir and Lady Kaye, Mr. and Mrs. Speers, Dr Gerold Dobler and Swarovski Optics, Earthwatch Institute, and Rafi Saar and Montal of Kibbutz Eilot. We thank Mick Marquiss and three anonymous referees for comments on an earlier version of the manuscript.

LITERATURE CITED

BILDSTEIN, K.L., W.S. CLARK, D.L. EVANS, F. MARSHALL, L SOUCY, AND E. HENCKEL. 1983. Sex and age differences in fall migration of Northern Harriers. *J. Field Ornithol.* 55:143–150.

CLARK, W.S. AND E. GORNEY. 1987. Oil contamination of raptors migrating along the Red Sea. *Environ. Pollut* 46:307–313.

——— AND R. YOSEF. 1997. Migrant Levant Sparrowhawks (*Accipiter brevipes*) at Eliat, Israel: measurements and timing. *J. Raptor Res.* 31:317–320.

——— AND ———. 1998. In-hand identification guide to palearctic raptors. International Birdwatching Centre in Eilat. Tech. Publ. 7, Eilat, Israel.

FRUMKIN, R., B. PINSHOW, AND S. KLEINHAUS. 1995. A review of bird migration over Israel. *J. Ornithol.* 136:127–147.

GORNEY, E. AND Y. YOM-TOV. 1994. Fat, hydration condition, and moult of steppe buzzards *Buteo buteo vulpinus* on spring migration. *Ibis* 136:185–192.

———, W.S. CLARK, AND Y. YOM-TOV. 1999. A test of the condition-bias hypothesis yields different results for two species of sparrowhawks (*Accipiter*). *Wilson Bull* 111:181–187.

HAGAR, J.A. 1988. Broad-winged Hawk: migration. Pages 1–25 *in* R.S. Palmer [ED.], Handbook of North American birds. Vol. 5. Yale Univ. Press, New Haven, CT U.S.A.

HOFFMAN, W. AND H. DARROW. 1992. Migration of diurnal raptors from the Florida Keys into the West Indies. *HMANA Hawk Migration Stud.* 17:7–14.

KERLINGER, P. 1989. Flight strategies of migrating hawks Univ. of Chicago Press, Chicago, IL U.S.A.

KRÓL, W. 1983. Bird ringing results in Poland. Migration of the buzzards *Buteo buteo buteo. Acta Ornithol.* 19:137–151.

MUELLER, H.C. AND K. MEYER. 1985. The evolution of reversed sexual dimorphism in size—a comparative analysis of the Falconiformes of the western palearctic. *Curr. Ornithol.* 2:65–101.

NEWTON, I. 1979. Population ecology of raptors. Buteo Books, Vermillion, SD U.S.A.

PIERSMA, T. AND N.C. DAVIDSON. 1991. Confusion of mass and size. *Auk* 108:441–444.

SAFRIEL, U. 1968. Bird migration at Eilat, Israel. *Ibis* 110: 283–320.

SHIRIHAI, H. 1996. The birds of Israel. Academic Press, London, U.K.

——— AND D. CHRISTIE. 1992. Raptor migration at Eilat. *Br. Birds* 85:141–186.

———, R. YOSEF, D. ALON, G. KIRWAN, AND R. SPAAR. 2000. Raptor migration in Israel and the Middle East—a summary of 30 years of field research. International Birding & Research Centre in Eilat, Eilat, Israel.

SNOW, D.W. AND C.M. PERRINS. [EDS.] 1998. The birds of the western palearctic. Vol. 1. Non-passerines. Oxford Univ. Press, Oxford, U.K.

SOKAL, R.R. AND F. J. ROHLF. 1995. Biometry, 3rd Ed. Freeman Press, New York, NY U.S.A.

SPAAR, R. 1997. Flight strategies of migrating raptors: a comparative study of interspecific variation in flight characteristics. *Ibis* 139:523–535.

———, H. STARK, AND F. LIECHTI. 1998. Migratory flight strategies of Levant Sparrowhawks: time or energy minimization? *Anim. Behav.* 56:1185–1197.

STARK, H. AND F. LIECHTI. 1993. Do Levant Sparrowhawks *Accipiter brevipes* also migrate at night? *Ibis* 135:233–236.

WYLLIE, I. AND I. NEWTON. 1994. Latitudinal variation in the body-size of Sparrowhawks *Accipiter nisus* within Britain. *Ibis* 136: 434–440.

YOSEF, R. 1995. Spring 1994 raptor migration at Eilat, Israel. *J. Raptor Res.* 29:127–134.

———. 1996a. Raptors feeding on migration at Eilat, Israel: opportunistic behavior or migration strategy? *J Raptor Res.* 30:242–245.

———. 1996b. Sex and age classes of migrating raptors during the spring of 1994 at Eilat, Israel. *J. Raptor Res* 30:160–164.

———. AND D. ALON. 1997. Do immature palearctic Egyptian Vultures *Neophron percnopterus* remain in Africa during the northern summer? *Vögelwelt* 118:285–289.

———. AND L. FORNASARI. 2000. Biometric differences between age and sex classes of the Levant Sparrowhawk *Accipiter brevipes* on migration at Eilat, Israel. *Israel J. Zool.* 46:207–214.

———, P. TRYJANOWSKI, AND K.L. BILDSTEIN. 2002. Spring migration of adult and immature Buzzards (*Buteo buteo*) through Eilat, Israel: timing and body size. *J. Raptor Res.* 36:115–120.

ZALLES, J.J. AND K.L. BILDSTEIN. (EDS.) 2000. Raptor watch: a global directory of raptor migration sites. BirdLife Conservation Series No. 9. BirdLife International, Cambridge, U.K. and Hawk Mountain Sanctuary. Kempton, PA U.S.A.

Received 19 December 2001; accepted 9 September 2002